

Table 1. Descriptive data for Rocky Flats production era cohort, 1952-1989

Variable	No.	Percent
Subjects in cohort	16,303	
Person-years	362,617	
Race and ethnicity		
White, non-Hispanic	14,581	89.4
White, Hispanic	1,034	6.3
Black	474	2.9
Other	214	1.3
Sex		
Male	13,381	82.1
Female	2,922	17.9
Vital status		
Alive	14,182	87.0
Deceased	2,121	13.0
Birth Year		
1890-1909	418	2.6
1910-1929	3,751	23.0
1930-1949	7,454	45.7
1950-1971	4,680	28.7
Year first hired		
1949-1953	1,161	7.1
1954-1959	1,319	8.1
1960-1967	2,787	17.1
1968-1989	11,036	67.7
Year last terminated		
1952-1969	2,531	15.5
1970-1979	2,946	18.1
1980-1989	4,441	27.2
>1989	6,385	39.2
Length of employment (years)		
≤5	5,938	36.4
5.1–10	2,860	17.5
10.1–20	4,922	30.2
20.1–30	1,942	11.9
>30	641	3.9
Year of Death		
1952-1967	103	4.9
1968-1978	345	16.3
1979-1987	607	28.6
1988-1996	1,066	50.3

Table 2. Standardized mortality ratios computed with U.S. rates for selected causes of death, both genders and all races, Rocky Flats production era cohort, 1952 – 1989

Cause of death (ICD9 Code*)	Observed	Expected	SMR	95% CI
All causes (001 - 999)	2,121	3,313.47	0.64	0.61, 0.67
All cancers (140 - 239)	640	858.46	0.75	0.69, 0.81
Buccal cavity (140 -149)	11	21.29	0.52	0.26, 0.92
Pharynx (146 -149)	2	10.57	0.19	0.02, 0.68
Digestive Organs and Peritoneum (150 – 159)	173	204.84	0.84	0.72, 0.98
Esophagus (150)	15	22.97	0.65	0.37, 1.08
Stomach (151)	29	27.19	1.07	0.71, 1.53
Intestine (152, 153)	59	73.59	0.80	0.61, 1.03
Rectum (154)	17	15.93	1.07	0.62, 1.71
Biliary passages and liver (155.0 - 155.1, 156)	10	14.94	0.67	0.32, 1.23
Liver, not specified (155.2)	1	5.66	0.18	0.00, 0.98
Pancreas (157)	41	41.45	0.99	0.71, 1.34
Respiratory and intrathoracic organs (160 – 165)	195	313.69	0.62	0.54, 0.72
Larynx (161)	5	10.58	0.47	0.15, 1.10
Trachea, bronchus, & lung (162)	187	299.99	0.62	0.54, 0.72
Breast (174 -175)	17	18.86	0.90	0.52, 1.44
Prostate (185)	57	56.09	1.02	0.77, 1.32
Kidney (189.0-2)	15	21.24	0.71	0.39, 1.16
Bladder (188, 189.3 - 189.9)	14	18.59	0.75	0.41, 1.26
Malignancies of other & unspecified sites	101	110.98	0.91	0.74, 1.11
Skin (172, 173)	18	18.77	0.96	0.57, 1.52
Brain &other central nervous system (191, 192)	31	24.97	1.24	0.84, 1.76
Bone (170)	1	2.20	0.45	0.01, 2.52
Connective tissue (171)	8	5.03	1.59	0.68, 3.13
Thyroid Gland (193)	1	1.50	0.67	0.02, 3.70
All lymphatic and hematopoietic	52	80.55	0.65	0.48, 0.85
Lymphosarcoma & reticulosarcoma (200)	7	7.78	0.90	0.36, 1.85
All leukemia (204-208)	20	30.79	0.65	0.40, 1.00
Other lymphatic and hematopoietic (202, 203)	23	36.55	0.63	0.40, 0.94
Unspecified neoplasms, nervous system‡	9	4.58	1.97	0.90, 3.73
Anemias, other & unspecified§	6	3.82	1.57	0.57, 3.42
Other diseases of the nervous system¶	46	45.61	1.01	0.74, 1.35
Diseases of the heart#	691	1,142.08	0.61	0.56, 0.65
Other diseases of the circulatory system**	138	246.98	0.56	0.47, 0.66
Respiratory diseases††	100	114.61	0.87	0.71, 1.06
Cirrhosis of the liver (571)	32	86.18	0.37	0.25, 0.52
Accidents (E800-E949)	116	197.27	0.59	0.49, 0.71
Homicide (E960-E978)	11	45.48	0.24	0.12, 0.43

\* ICD9, International Classification of Diseases, Ninth Revision; SMR, standardized mortality ratio.

† ICD codes 172, 173, 190, 191, 192, 193, 170, 171, 194 – 199

‡ ICD codes 237.5 – 237.9, 239.6 – 239.7

§ ICD codes § 280, 281.1 - 281.8, 282 – 285

¶ ICD codes 340, 320 – 337, 341 – 389

# ICD codes 390 – 398, 410 – 414, 424, 429.0 – 429.1, 402, 404, 420 – 423, 425 – 428, 429.2 – 424.9

\*\* ICD codes 401, 403, 405, 415 – 417, 430 – 438, 440 – 459

†† ICD codes 470 - 478, 494 – 519

Table 3. Standardized mortality ratios computed with Colorado rates for selected causes of death, both genders and all races, Rocky Flats production era cohort 1952-1989

Cause of death (ICD9 Code*)	Observed	Expected	SMR	95% CI
All causes (001 - 999)	2,107	2,879.15	0.73	0.70, 0.76
All cancers (140 - 239)	636	696.88	0.91	0.84, 0.99
Buccal cavity (140 -149)	11	14.34	0.77	0.38, 1.37
Pharynx (146 -149)	2	6.65	0.30	0.04, 1.09
Digestive Organs and Peritoneum (150 – 159)	172	174.04	0.99	0.85, 1.15
Esophagus (150)	15	18.36	0.82	0.46, 1.35
Stomach (151)	28	24.33	1.15	0.76, 1.66
Intestine (152, 153)	59	61.10	0.97	0.74, 1.25
Rectum (154)	17	12.44	1.37	0.80, 2.19
Biliary passages and liver (155.0 - 155.1, 156)	10	14.17	0.71	0.34, 1.30
Liver, not specified (155.2)	1	2.61	0.38	0.01, 2.13
Pancreas (157)	41	38.22	1.07	0.77, 1.46
Respiratory and intrathoracic organs (160 – 165)	193	224.61	0.86	0.74, 1.00
Larynx (161)	4	6.88	0.58	0.16, 1.49
Trachea, bronchus, & lung (162)	186	214.60	0.87	0.75, 1.00
Breast (174 -175)	17	16.43	1.03	0.60, 1.66
Prostate (185)	57	58.47	0.97	0.74, 1.26
Kidney (189.0.-2)	15	18.14	0.83	0.46, 1.36
Bladder (188, 189.3 - 189.9)	14	16.14	0.87	0.47, 1.46
Malignancies of other & unspecified sites†	100	91.65	1.09	0.89, 1.33
Skin (172, 173)	18	18.88	0.95	0.56, 1.51
Brain &other central nervous system (191, 192)	31	23.59	1.31	0.89, 1.87
Bone (170)	1	1.60	0.62	0.02, 3.47
Connective tissue (171)	7	4.97	1.41	0.56, 2.90
Thyroid Gland (193)	1	1.39	0.72	0.02, 3.99
All lymphatic and hematopoietic	52	72.42	0.72	0.54, 0.94
Lymphosarcoma & reticulosarcoma (200)	7	7.14	0.98	0.39, 2.02
All leukemia (204-208)	20	28.27	0.71	0.43, 1.09
Other lymphatic and hematopoietic (202, 203)	23	32.23	0.71	0.45, 1.07
Unspecified neoplasms, nervous system‡	9	3.59	2.51	1.14, 4.76
Anemias, other & unspecified§	6	3.39	1.77	0.65, 3.85
Other diseases of the nervous system¶	45	50.00	0.90	0.66, 1.20
Diseases of the heart #	681	879.98	0.77	0.72, 0.83
Other diseases of the circulatory system**	138	216.68	0.64	0.54, 0.75
Respiratory diseases††	100	149.99	0.67	0.54, 0.81
Cirrhosis of the liver (571)	32	78.48	0.41	0.28, 0.58
Accidents (E800-E949)	117	200.25	0.58	0.48, 0.70
Homicide (E960-E978)	11	34.46	0.32	0.16, 0.57

\* ICD9, International Classification of Diseases, Ninth Revision; SMR, standardized mortality ratio.

† ICD codes 172, 173, 190, 191, 192, 193, 170, 171, 194 – 199

‡ ICD codes 237.5 – 237.9, 239.6 – 239.7

§ ICD codes § 280, 281.1 - 281.8, 282 – 285

¶ ICD codes 340, 320 – 337, 341 – 389

# ICD codes 390 – 398, 410 – 414, 424, 429.0 – 429.1, 402, 404, 420 – 423, 425 – 428, 429.2 – 424.9

\*\* ICD codes 401, 403, 405, 415 – 417, 430 – 438, 440 – 459

†† ICD codes 470 - 478, 494 – 519

Table 4. Standardized mortality ratios computed with U.S. rates for selected causes of death, white males only, Rocky Flats production era cohort 1952-1989

Cause of death (ICD9 Code*)	Observed	Expected	SMR	95% CI
All causes (001 - 999)	1,892	2,862.29	0.66	0.63, 0.69
All cancers (140 - 239)	557	735.25	0.76	0.70, 0.82
Buccal cavity (140 -149)	10	18.23	0.55	0.26, 1.01
Pharynx (146 -149)	2	8.91	0.22	0.03, 0.81
Digestive Organs and Peritoneum (150 – 159)	152	177.70	0.86	0.72, 1.00
Esophagus (150)	15	19.57	0.77	0.43, 1.26
Stomach (151)	25	23.58	1.06	0.69, 1.56
Intestine (152, 153)	54	64.22	0.84	0.63, 1.10
Rectum (154)	14	14.14	0.99	0.54, 1.66
Biliary passages and liver (155.0 - 155.1, 156)	8	12.43	0.64	0.28, 1.27
Liver, not specified (155.2)	1	4.81	0.21	0.01, 1.16
Pancreas (157)	34	36.21	0.94	0.65, 1.31
Respiratory and intrathoracic organs (160 – 165)	178	279.72	0.64	0.55, 0.74
Larynx (161)	4	9.35	0.43	0.12, 1.09
Trachea, bronchus, & lung (162)	172	267.60	0.64	0.55, 0.75
Breast (174 -175)	0	0.87	0.00	0.00, 4.19
Prostate (185)	54	52.76	1.02	0.77, 1.34
Kidney (189.0-.2)	13	19.18	0.68	0.36, 1.16
Bladder (188, 189.3 - 189.9)	14	17.47	0.80	0.44, 1.34
Malignancies of other & unspecified sites†	88	96.40	0.91	0.73, 1.12
Skin (172, 173)	18	17.10	1.05	0.62, 1.66
Brain &other central nervous system (191, 192)	28	22.03	1.27	0.84, 1.84
Bone (170)	0	1.90	0.00	0.00, 1.94
Connective tissue (171)	7	4.13	1.69	0.68, 3.49
Thyroid Gland (193)	1	1.27	0.79	0.02, 4.36
All lymphatic and hematopoietic	47	70.37	0.67	0.49, 0.89
Lymphosarcoma & reticulosarcoma (200)	7	7.01	1.00	0.40, 2.06
All leukemia (204-208)	18	27.03	0.67	0.39, 1.05
Other lymphatic and hematopoietic (202, 203)	20	31.63	0.63	0.39, 0.98
Unspecified neoplasms, nervous system‡	9	3.90	2.31	1.05, 4.39
Anemias, other & unspecified§	6	2.80	2.15	0.78, 4.67
Other diseases of the nervous system¶	40	38.73	1.03	0.74, 1.41
Diseases of the heart#	644	1,034.95	0.62	0.58, 0.67
Other diseases of the circulatory system**	125	210.52	0.59	0.49, 0.71
Respiratory diseases††	89	103.09	0.86	0.69, 1.06
Cirrhosis of the liver (571)	27	72.89	0.37	0.24, 0.54
Accidents (E800-E949)	103	165.24	0.62	0.51, 0.76
Homicide (E960-E978)	5	25.02	0.20	0.06, 0.47

\* ICD9, International Classification of Diseases, Ninth Revision; SMR, standardized mortality ratio.

† ICD codes 172, 173, 190, 191, 192, 193, 170, 171, 194 – 199

‡ ICD codes 237.5 – 237.9, 239.6 – 239.7

§ ICD codes § 280, 281.1 - 281.8, 282 – 285

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Table 5. Standardized mortality ratios computed with Colorado rates for selected causes of death, white males only, Rocky Flats production era cohort, 1952-1989

Cause of death (ICD9 Code*)	Observed	Expected	SMR	95% CI
All causes (001 - 999)	1,878	2,528.60	0.74	0.71, 0.78
All cancers (140 - 239)	553	599.79	0.92	0.85, 1.00
Buccal cavity (140 -149)	10	12.43	0.80	0.39, 1.48
Pharynx (146 -149)	2	5.77	0.35	0.04, 1.25
Digestive Organs and Peritoneum (150 – 159)	151	150.85	1.00	0.85, 1.17
Esophagus (150)	15	16.43	0.91	0.51, 1.51
Stomach (151)	24	21.35	1.12	0.72, 1.67
Intestine (152, 153)	54	52.84	1.02	0.77, 1.33
Rectum (154)	14	10.80	1.30	0.71, 2.18
Biliary passages and liver (155.0 - 155.1, 156)	8	11.21	0.71	0.31, 1.41
Liver, not specified (155.2)	1	2.29	0.44	0.01, 2.42
Pancreas (157)	34	33.45	1.02	0.70, 1.42
Respiratory and intrathoracic organs (160 – 165)	176	202.32	0.87	0.75, 1.01
Larynx (161)	3	6.21	0.48	0.10, 1.41
Trachea, bronchus, & lung (162)	171	193.31	0.88	0.76, 1.03
Breast (174 -175)	0	0.54	0.00	0.00, 6.86
Prostate (185)	54	56.13	0.96	0.72, 1.26
Kidney (189.0-2)	13	15.93	0.82	0.43, 1.40
Bladder (188, 189.3 - 189.9)	14	15.26	0.92	0.50, 1.54
Malignancies of other & unspecified sites†	87	80.56	1.08	0.87, 1.33
Skin (172, 173)	18	17.26	1.04	0.62, 1.65
Brain &other central nervous system (191, 192)	28	20.92	1.34	0.89, 1.93
Bone (170)	0	1.40	0.00	0.00, 2.63
Connective tissue (171)	6	4.15	1.45	0.53, 3.15
Thyroid Gland (193)	1	1.06	0.95	0.02, 5.25
All lymphatic and hematopoietic	47	63.46	0.74	0.54, 0.99
Lymphosarcoma & reticulosarcoma (200)	7	6.31	1.11	0.44, 2.29
All leukemia (204-208)	18	25.00	0.72	0.43, 1.14
Other lymphatic and hematopoietic (202, 203)	20	28.03	0.71	0.44, 1.10
Unspecified neoplasms, nervous system‡	9	3.13	2.88	1.31, 5.46
Anemias, other & unspecified§	6	2.64	2.64	0.83, 4.95
Other diseases of the nervous system¶	40	43.63	0.92	0.65, 1.25
Diseases of the heart§§	637	808.27	0.79	0.73, 0.85
Other diseases of the circulatory system**	124	188.45	0.66	0.55, 0.78
Respiratory diseases††	89	138.30	0.64	0.52, 0.79
Cirrhosis of the liver (571)	27	67.46	0.40	0.26, 0.58
Accidents (E800-E949)	103	172.81	0.60	0.49, 0.72
Homicide (E960-E978)	5	21.11	0.24	0.08, 0.55

\* ICD9, International Classification of Diseases, Ninth Revision; SMR, standardized mortality ratio.

† ICD codes 172, 173, 190, 191, 192, 193, 170, 171, 194 – 199.

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Table 6. Frequencies of mortality and cancer incidence classifications for selected causes of death and cancer diagnoses, Rocky Flats production era cohort 1952–1989

Cause of death (ICD9 Code*)	UCD	MCD	Cancer incidence
All causes (001 - 999)	2,121	5,411	NA
All cancers (140 - 239)	640	946	1,267
Buccal cavity (140 -149)	11	12	28
Pharynx (146 -149)	2	2	3
Digestive Organs and Peritoneum (150 – 159)	173	190	242
Esophagus (150)	15	15	8
Stomach (151)	29	30	29
Intestine (152, 153)	59	69	107
Rectum (154)	17	22	61
Biliary passages and liver (155.0 - 155.1, 156)	10	11	6
Liver, not specified (155.2)	1	1	4
Pancreas (157)	41	41	24
Respiratory and intrathoracic organs (160 – 165)	195	208	173
Larynx (161)	5	6	16
Trachea, bronchus, & lung (162)	187	199	144
Breast (174 -175)	17	18	76
Prostate (185)	57	70	325
Kidney (189.0-.2)	15	17	26
Bladder (188, 189.3 - 189.9)	14	17	81
Malignancies of other & unspecified sites†	101	340	149
Skin (172, 173)	18	19	68
Brain & other central nervous system (191, 192)	31	32	53‡
Bone (170)	1	2	1
Connective tissue (171)	8	8	11§
Thyroid Gland (193)	1	2	20
All lymphatic and hematopoietic	52	64	111
Lymphosarcoma & reticulosarcoma (200)	7	9	0
All leukemia (204-208)	20	26	49
Other lymphatic and hematopoietic (202, 203)	23	25	51
Unspecified neoplasms, nervous system¶	9	10	NA
Anemias, other & unspecified #	6	23	NA
Other diseases of the nervous system**	46	149	NA
Diseases of the heart††	691	1,585	NA
Other diseases of the circulatory system‡‡	138	448	NA
Respiratory diseases§§	100	257	NA
Cirrhosis of the liver (571)	32	45	NA
Accidents (E800-E949)	116	440	NA
Homicide (E960-E978)	11	24	NA

\* ICD9, International Classification of Diseases, Ninth Revision; UCD, underlying cause of death; MCD, multiple causes of death, including UCDs; NA, not assessed.

† ICD codes 172, 173, 190, 191, 192, 193, 170, 171, 194 – 199.

‡ International Classification of Diseases for Oncology, Second Revision (ICD-O) codes 700 – 729, 751.

§ ICD-O codes 490 – 499 (includes soft tissue and subcutaneous tissues).

¶ ICD codes 237.5 – 237.9, 239.6 – 239.7.

# ICD codes 280, 281.1 - 281.8, 282 – 285.

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§§ ICD codes 470 - 478, 494 – 519.

Table 7. Descriptive data for subject groups in case-control analyses, Rocky Flats production era, 1952-1989

Variable	All subjects				Subjects with smoking data				Matched case-control pairs with smoking data			
	Cases		Controls		Cases		Controls		Cases		Controls	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Number of subjects	180		720		123		607		123		426	
Sex												
Male	173	96.0	692	96.0	119	96.7	587	96.7	119	96.7	412	96.7
Female	7	4.0	28	4.0	4	3.3	20	3.3	4	3.3	14	3.3
Vital status												
Alive	0	0	501	69.6	0	0	449	74.0	0	0	320	75.1
Dead	180	100	219	30.4	123	100	158	26.0	123	100	106	24.9
Period of first hire	180		718*		123		607		123		426	
1951-1953	38	21.1	186	25.8	23	18.7	157	25.9	23	18.7	120	28.2
1954-1959	40	22.2	175	24.3	27	22.0	140	23.1	36	29.3	104	24.4
1960-1967	64	35.6	175	24.3	41	33.3	145	23.9	33	26.8	100	23.5
1968-1989	38	21.1	182	25.3	32	26.0	165	27.2	31	25.2	102	23.9
	Mean		Mean		Mean		Mean		Mean		Mean	
Employment length (yr)	11.6		13.9		13.1		14.1		13.1		15.2	
Age, first lung dose (yr)	48		47		48		46		48		45	
Age at death (yr)	66		75		65		74		65		74	

\* Hire dates are missing for 2 control subjects; percentages are based on the total number of controls in each of the three subject groups.

† Internal dose from plutonium and uranium isotopes.

Table 8. Univariate odds ratios for cumulative internal lung dose variables, all cases and controls, Rocky Flats production era, 1952-1989

Lung Dose Variable*	Cases		Controls		OR	95% CI
	No.	%	No.	%		
Continuous dose (mSv)	180	100	718†	99.7	1.00	1.00, 1.00
Dichotomous						
Lung Dose = 0 mSv	93	51.7	386	53.8	1.0	
Lung Dose > 0 mSv	87	48.3	332	46.2	1.10	0.78, 1.56
Continuous categorical‡	180	100	718	99.7	1.06	0.91, 1.24
Four design variables						
0	93	51.7	386	53.8	1.0	
>0-100 mSv	33	18.3	127	17.6	1.09	0.69, 1.72
>100-400 mSv	21	11.7	97	13.5	0.90	0.51, 1.56
>400 mSv	33	18.3	108	28.0	1.31	0.81, 2.12
Six design variables						
0	93	51.7	386	53.6	1.0	
>0-100 mSv	33	18.3	127	17.6	1.10	0.70, 1.74
>100-400 mSv	21	11.7	97	13.5	0.89	0.51, 1.55
>400-644 mSv	13	7.2	34	4.7	1.62	0.80, 3.27
>644-940 mSv	12	6.7	34	4.7	1.53	0.74, 3.16
>940 mSv	8	4.4	40	5.6	0.83	0.30, 1.72

\* All doses lagged by 10 years.

† Cumulative lung dose data are missing for two control subjects; percentages based on total number of controls.

‡ Categories are the same as for 4-group design variable.

Table 9. Univariate odds ratios for selected variables, all cases and controls, Rocky Flats production era, 1952-1989

Model variable	Cases		Controls		OR†	95% CI
	No.	%	No.	%		
Cumulative penetrating radiation dose (mSv)*						
0	25	13.9	103	14.3	1.0	
>0-50	126	70.0	504	70.2	1.05	0.61, 1.80
>50	29	16.1	111	15.5	1.11	0.57, 2.17
Period of first hire						
1951–1953	38	21.1	186	25.8	0.98	0.57, 1.69
1954–1959	40	22.2	175	24.3	1.09	0.64, 1.87
1960–1967	64	35.6	175	24.3	1.74	1.09, 2.79
1968–1989	38	21.1	182	25.3	1.0	
Length of employment (years)	180	100	718	99.7	0.97	0.96, 0.99
Age, first internal lung dose (years)	98	54.4	412	57.2	1.04	0.99, 1.09
Smoking frequency (pack-years)‡						
0	75	10.0	329	30.0	1.0	
0.1-12.8	21	11.7	109	15.0	2.18	1.21, 4.71
>12.8-25.5	21	11.1	95	13.5	2.38	1.39, 5.11
>25.5-43.0	23	13.3	104	14.3	2.67	3.09, 10.66
>43.0	40	22.2	83	11.5	5.74	3.47, 11.36
Missing	57	31.7	113	15.7		

\* 10-year lag period.

† Logistic regression model, adjusted for birth year.

‡ Indicator variable for missing smoking data.

Table 10. Univariate odds ratios for cumulative internal lung dose by length of employment, all cases and controls, Rocky Flats production era, 1952-1989

Cumulative internal lung dose*	Number of subjects				OR†	95% CI		
	Cases		Controls					
	No.	%	No.	%				
Employed ≤10 years								
0	72	76.6	236	79.7	1.0			
>0-100 mSv	18	19.2	40	13.5	1.47	0.80, 2.73		
>100-400 mSv	3	3.2	10	3.4	0.98	0.26, 3.67		
>400 mSv	1	1.1	10	3.4	0.33	0.05, 2.36		
Employed 5-15 years								
0	39	57.4	153	63.2	1.0			
>0-100 mSv	13	19.1	47	19.4	1.10	0.54, 2.22		
>100-400 mSv	7	10.3	20	8.3	1.43	0.56, 3.66		
>400 mSv	9	13.2	22	9.1	1.60	0.68, 3.75		
Employed 10-20 years								
0	20	33.3	117	50.2	1.0			
>0-100 mSv	12	20.0	47	20.2	1.57	0.71, 3.49		
>100-400 mSv	9	15.0	32	13.7	1.79	0.73, 4.38		
>400 mSv	19	31.7	37	15.9	2.99	1.45, 6.17		
15-25 years								
0	13	22.0	84	37.3	1.0			
>0-100 mSv	10	15.3	51	22.7	1.21	0.50, 2.97		
>100-400 mSv	14	23.7	46	20.4	1.86	0.77, 4.34		
>400 mSv	23	39.0	44	19.6	3.36	1.57, 7.22		
Employed 20-30 years								
0	8	20.5	53	27.0	1.0			
>0-100 mSv	5	12.8	45	22.5	0.61	0.19, 1.94		
>100-400 mSv	9	23.1	50	26.0	0.86	0.30, 2.49		
>400 mSv	17	43.6	48	24.5	2.20	0.88, 5.52		
Employed >25 years								
0	6	37.5	20	17.0	1.0			
>0-100 mSv	2	12.5	21	17.8	0.25	0.04, 1.49		
>100-400 mSv	4	25.0	35	29.7	0.29	0.07, 1.27		
>400 mSv	4	25.0	42	35.6	0.25	0.06, 1.05		

\* 10- year lag period.

† Conditional logistic regression model, all cases and controls.

Table 11. Multiple logistic regression analysis for workers employed for 15-25 years, all cases and controls, Rocky Flats production era, 1952-1989

Model variables	Cases		Controls		OR	95% CI
	No.	%	No.	%		
Cumulative internal lung dose (mSv)*						
0	13	21.7	84	37.3	1.0	
>0-100	10	16.7	51	22.7	1.14	0.46, 2.86
>100-400	14	23.3	46	20.4	2.11	0.86, 5.20
>400-644	7	11.7	17	7.6	2.74	0.92, 8.19
>644-940	9	15.0	16	7.1	3.20	1.15, 8.94
>940	7	11.7	11	4.9	5.04‡	1.55, 16.40
Period of first hire						
1951–1953	9	15.0	70	31.1	1.05	0.25, 4.38
1954–1959	19	31.7	64	28.4	1.55	0.50, 4.86
1960–1967	22	36.7	50	22.2	2.56	0.91, 7.21
1968–1989	10	16.7	41	18.2	1.0	
Length of employment (years)	60	100	225	100	0.87	0.79, 0.97

\* 10-year lag period.

† Modeled as a continuous variable in units of years.

‡ Chi-square statistic for linear trend = 67.2 ( $p < 0.001$ ).

Table 12. Univariate odds ratios for cumulative internal lung dose by period of first hire, all cases and controls, Rocky Flats production era, 1952-1989

Cumulative internal lung dose*	Subjects				OR†	95% CI
	Cases		Controls			
	No.	%	No.	%		
1951-1960						
0	49	55.7	198	50.8	1.0	
>0-100 mSv	16	18.2	67	17.8	0.98	0.52, 1.84
>100-400 mSv	9	10.2	46	11.8	0.82	0.38, 1.81
>400 mSv	14	15.1	79	20.3	0.73	0.38, 1.40
1955-1965						
0	43	46.7	147	49.0	1.0	
>0-100 mSv	20	21.7	55	18.3	1.24	0.67, 2.30
>100-400 mSv	7	7.6	32	10.7	0.75	0.31, 1.83
>400 mSv	22	23.9	66	22.0	1.14	0.63, 2.06
1960-1970						
0	34	43.6	129	53.1	1.0	
>0-100 mSv	16	20.5	42	17.3	1.43	0.72, 2.86
>100-400 mSv	9	11.5	42	17.3	0.79	0.35, 1.79
>400 mSv	19	24.4	30	11.5	2.37	1.19, 4.72
1965-1975						
0	10	35.7	68	51.5	1.0	
>0-100 mSv	4	14.3	21	15.9	1.29	0.36, 4.61
>100-400 mSv	7	25.0	36	27.3	1.32	0.45, 3.82
>400 mSv	7	25.0	7	5.3	6.77	1.84, 24.84
1970 or later						
0	15	55.6	81	63.8	1.0	
>0-100 mSv	4	14.8	28	22.1	0.75	0.23, 2.40
>100-400 mSv	5	18.5	16	12.6	1.76	0.56, 5.54
>400 mSv	3	11.1	2	1.6	9.46	1.41, 63.26
1972 or later						
0	15	65.2	72	67.9	1.0	
>0-100 mSv	3	13.0	24	22.6	0.60	0.17, 2.18
>100-400 mSv	4	17.4	9	8.5	2.14	0.58, 7.86
>400 mSv	1	4.4	1	0.9	5.13	0.30, 88.51

\* 10-year lag period.

† Logistic regression model, adjusted for birth year.

Table 13. Conditional multiple logistic regression analysis for case-control pairs with smoking data, Rocky Flats production era, 1952-1989

Model variables	Cases (n=123)		Controls (n=426)		OR	95% CI
	No.	%	No.	%		
Cumulative internal lung dose (mSv)*						
0	55	44.7	206	48.4	1.0	
>0-100	22	17.9	84	19.7	1.14	0.58, 2.23
>100-400	17	13.8	63	14.8	1.84	0.83, 4.09
>400	29	23.6	73	17.1	2.28	0.96, 5.41
Cumulative penetrating radiation dose (mSv)*						
0	17	13.8	61	14.3	1.0	
>0-50	80	65.0	294	69.0	1.36	0.62, 2.98
>50	26	21.1	71	16.7	1.54	0.51, 4.48
Smoking frequency (pack-years)*						
0	18	14.6	153	35.9	1.0	
0.1-12.8	21	17.1	74	17.4	2.31	1.14, 4.71
>12.8-25.5	21	17.1	73	17.1	2.51	1.23, 5.12
>25.5-43.0	23	18.7	71	16.7	2.97	1.45, 6.11
>43.0	40	32.5	55	12.9	6.85	3.47, 13.52
Length of employment (years)	123	100	426	100	0.96	0.93, 0.99

\*10-year lag period.

Table 14. Multiple logistic regression analysis for subjects with smoking data, adjusted for age at first internal lung dose, Rocky Flats production era, 1952-1989

Model variables	Cases (n=76)		Controls (n=268)		OR*	95% CI
	No.	%	No.	%		
Cumulative internal lung dose (mSv)†						
0	8	10.5	48	17.9	1.0	
>0-100	22	28.9	84	31.3	1.33	0.35, 5.01
>100-400	17	22.4	63	23.5	2.10	0.53, 8.35
>400	29	38.2	73	27.2	3.26	0.76, 13.93
Cumulative penetrating radiation dose (mSv)†						
0	5	6.6	34	12.7	1.0	
>0-50	47	61.8	166	61.9	2.32	0.50, 10.80
>50	24	31.6	68	25.4	2.61	0.45, 15.19
Smoking frequency (pack-years)†						
0	10	13.2	87	32.5	1.0	
0.1-12.8	12	15.8	51	19.0	2.17	0.85, 5.54
>12.8-25.5	13	17.1	50	18.7	2.16	0.86, 5.43
>25.5-43.0	15	19.7	51	19.0	2.72	1.09, 6.84
>43.0	26	34.2	29	10.8	7.26	3.03, 17.41
Length of employment (years)	76	100	268	100	0.94	0.91, 0.98
Age, first lung dose (years)	76	100	268	100	1.00	1.01, 1.10

\* Logistic regression model, adjusted for birth year.

† 10-year lag period.

Table 15. Multiple logistic regression analysis for case and control subjects with smoking data, Rocky Flats production era, 1952-1989

Model variables	Cases (n=123)		Controls (n=607)		OR*	95% CI
	No.	%	No.	%		
Cumulative internal lung dose (mSv)†						
0	55	44.7	304	50.1	1.0	
>0-100	22	17.9	114	18.8	1.28	0.70, 2.33
>100-400	17	13.8	90	14.8	1.64	0.80, 3.36
>400	29	23.6	99	16.3	2.57	1.22, 5.43
Cumulative penetrating radiation dose (mSv)†						
0	17	13.8	85	14.0	1.0	
>0-50	80	65.0	420	69.2	0.86	0.45, 1.66
>50	26	21.1	102	16.8	0.82	0.33, 2.08
Smoking frequency (pack-years)†						
0	18	14.6	216	35.6	1.0	
0.1-12.8	21	17.1	109	18.0	2.26	1.15, 4.46
>12.8-25.5	21	17.1	95	15.7	2.62	1.33, 5.17
>25.5-43.0	23	18.7	104	17.1	2.64	1.35, 5.15
>43.0	40	32.5	83	13.7	5.68	3.06, 10.50
Length of employment (years)	123	100	607	100	0.96	0.94, 0.99

\* Adjusted for birth year.

† 10-year lag period.

Table 16. Multiple logistic regression analysis for cases and controls with smoking data, adjusted for age at first lung dose, Rocky Flats production era, 1952-1989

Model variables	Cases (n=76)		Controls (n=372)		OR*	95% CI
	No.	%	No.	%		
Cumulative internal lung dose (mSv)†						
0	8	10.5	69	18.5	1.0	
>0-100	22	28.9	114	30.6	1.52	0.44, 5.23
>100-400	17	22.4	90	24.2	2.02	0.57, 7.18
>400	29	38.2	99	26.6	3.75	0.98, 14.36
Cumulative penetrating radiation dose (mSv)†						
0	5	6.6	44	11.8	1.0	
>0-50	47	61.8	232	62.4	2.03	0.48, 8.67
>50	24	31.6	96	25.8	2.08	0.40, 10.85
Smoking frequency (pack-years)†						
0	10	13.2	118	31.7	1.0	
0.1-12.8	12	15.8	75	20.2	2.09	0.85, 5.16
>12.8-25.5	13	17.1	60	16.1	2.39	0.97, 5.87
>25.5-43.0	15	19.7	73	19.6	2.71	1.12, 6.53
>43.0	26	34.2	46	12.4	6.30	2.76, 14.37
Length of employment (years)	76	100	372	100	0.95	0.91, 0.98
Age, first lung dose (years)	76	100	372	100	1.05	1.00, 1.09

\* Adjusted for birth year.

† 10-year lag period.

Table 17. Conditional multiple logistic regression analysis with missing-indicator variable for all case and control subjects. Rocky Flats production era, 1952-1989

Model variables	Cases (n=180)		Controls (n=718)		OR	95% CI
	No.	%	No.	%		
Cumulative internal lung dose (mSv)*						
0	93	51.7	386	53.8	1.0	
>0-100	33	18.3	127	17.6	1.42	0.86, 2.36
>100-400	21	11.7	97	13.5	1.74	0.91, 3.36
>400	33	18.3	108	28.0	2.56	1.28, 5.14
Cumulative penetrating radiation dose (mSv)*						
0	25	13.9	103	14.3	1.0	
>0-50	126	70.0	504	70.2	1.08	0.58, 2.01
>50	29	16.1	111	15.5	0.97	0.40, 2.25
Smoking frequency (pack-years)*						
0†	75	41.7	327	45.5	1.0	
0.1-12.8	21	11.7	109	15.2	2.15	1.09, 4.19
>12.8-25.5	21	11.7	95	13.2	2.52	1.27, 4.99
>25.5-43.0	23	12.8	104	14.5	2.51	1.29, 4.90
>43.0	40	22.2	83	11.6	5.61	2.99, 10.54
Length of employment (years)	180	100	718	100	0.97	0.94, 0.99

\* 10-year lag period.

† Zero pack-year category includes subjects with missing smoking data.

Table 18. Conditional multiple logistic regression analysis with missing-indicator variable for all case and control subjects, adjusted for age at first internal lung dose, Rocky Flats production era, 1952-1989

Model variables	Cases (n=98)		Controls (n=412)		OR	95% CI
	N	%	N	%		
Cumulative internal lung dose (mSv)*						
0	11	11.2	80	19.4	1.0	
>0-100	33	33.7	127	30.8	1.41	0.52, 3.84
>100-400	21	21.4	97	23.5	1.59	0.57, 4.48
>400	33	33.7	108	26.2	2.62	0.87, 7.94
Cumulative penetrating radiation dose (mSv)*						
0	5	5.1	50	12.1	1.0	
>0-50	66	67.3	258	62.6	2.85	0.79, 10.26
>50	27	27.6	104	25.2	2.90	0.66, 12.69
Smoking frequency (pack-years)*						
0†	32	32.7	158	38.3	1.0	
0.1-12.8	12	12.2	75	18.2	2.06	0.84, 5.07
>12.8-25.5	13	13.3	60	14.6	2.34	0.96, 5.73
>25.5-43.0	15	15.3	73	17.7	2.67	1.12, 6.39
>43.0	26	26.5	46	11.2	6.28	2.76, 14.25
Length of employment (years)	98	100	412	100	0.95	0.92, 0.98
Age, first lung dose (years)	98	100	412	100	1.04	1.01, 1.09

\* 10-year lag period.

† Zero pack-year category includes subjects with missing smoking data.

Table 19. Conditional multiple logistic regression analysis of case and control subjects, not adjusted for smoking frequency, Rocky Flats production era, 1952-1989

Model variables	Cases (n=180)		Controls (n=718)		OR	95% CI
	N	%	N	%		
Cumulative internal lung dose (mSv)*						
0	93	51.7	386	53.6	1.0	
>0-100	33	18.3	127	17.6	1.40	0.86, 2.30
>100-400	21	11.7	97	13.5	1.62	0.84, 3.13
>400	33	18.3	108	15.0	2.20†	1.13, 4.26
Cumulative penetrating radiation dose (mSv)*						
0	25	13.9	103	14.3	1.0	
>0-50	126	70.0	504	70.2	0.99	0.52, 1.88
>50	29	16.1	111	15.5	0.93	0.38, 2.28
Period of first hire						
1951–1953	38	21.1	186	25.8	1.33	0.71, 2.49
1954–1959	40	22.2	175	24.3	1.29	0.71, 2.36
1960–1967	64	35.6	175	24.3	1.84	1.10, 3.08
1968–1989	38	21.1	182	25.3	1.0	
Length of employment (years)	180	100	718	99.7	0.96	0.94, 0.98

\* 10-year lag period.

†Chi square for linear trend across dose categories = 5.92, p < 0.03.

Table 20. Conditional multiple logistic regression analysis, all case and control subjects, not adjusted for smoking frequency, six categories for cumulative internal lung dose, Rocky Flats production era, 1952-1989

Model variables	Cases (n=180)		Controls (n=718)		OR	95% CI
	N	%	N	%		
Cumulative internal lung dose (mSv)*						
0	93	51.7	386	53.6	1.0	
>0-100	33	18.3	127	17.6	1.42	0.87, 2.33
>100-400	21	11.7	97	13.5	1.60	0.83, 3.10
>400-644	13	7.2	34	4.7	2.71	1.20, 6.09
>644-940	12	6.7	34	4.7	2.30	0.96, 5.53
>940	8	4.4	40	5.6	1.48	0.56, 3.89
Cumulative penetrating radiation dose (mSv)*						
0	25	13.9	103	14.3	1.0	
>0-50	126	70.0	504	70.2	0.99	0.52, 1.87
>50	29	16.1	111	15.5	0.98	0.40, 2.41
Period of first hire						
1951–1953	38	21.1	186	25.9	1.36	0.72, 2.54
1954–1959	40	22.2	175	24.4	1.30	0.71, 2.37
1960–1967	64	35.6	175	24.4	1.82	1.08, 3.05
1968–1989	38	21.1	182	25.4	1.0	
Length of employment (years)	180	100	718	99.7	0.96	0.94, 0.98

\* 10-year lag period.

Table 21. Multiple logistic regression analysis of case and control subjects not adjusted for smoking frequency, adjusted for age at first internal lung dose, Rocky Flats production era, 1952-1989

Model variables	Cases (n=98)		Controls (n=412)		OR	95% CI
	N	%	N	%		
Cumulative internal lung dose (mSv)*						
0	11	11.2	80	19.4	1.0	
>0-100	33	33.7	127	30.8	1.43	0.56, 3.63
>100-400	21	21.4	97	23.5	1.75	0.65, 4.72
>400	33	33.7	108	26.2	2.45	0.87, 6.89
Cumulative penetrating radiation dose (mSv)*						
0	5	5.1	50	12.1	1.0	
>0-50	66	67.3	258	62.6	2.72	0.83, 8.92
>50	27	27.6	104	25.2	2.98	0.75, 11.88
Period of first hire						
1951–1953	13	13.3	93	22.6	1.35	0.47, 3.91
1954–1959	25	25.5	112	27.2	1.71	0.67, 4.37
1960–1967	36	36.7	91	22.1	2.45	1.15, 5.26
1968–1989	24	24.5	116	28.2	1.0	
Length of employment (years)	98	100	412	100	0.94	0.91, 0.97
Age, first lung dose (years)	98	100	412	100	1.05	1.01, 1.10

\* 10-year lag period.

Table 22. Conditional multiple logistic regression analysis, all case and control subjects, not adjusted for smoking frequency, six categories for cumulative internal lung dose, with adjustment for dose duration, Rocky Flats production era, 1952-1989

Model variables	Cases (n=180)		Controls (n=718)		OR	95% CI
	N	%	N	%		
Cumulative internal lung dose (mSv)*						
0	93	51.7	386	53.6	1.0	
>0-100	33	18.3	127	17.6	1.77	1.04, 3.02
>100-400	21	11.7	97	13.5	3.31	1.31, 8.38
>400-644	13	7.2	34	4.7	6.09	2.03, 18.31
>644-940	12	6.7	34	4.7	5.54	1.69, 18.19
>940	8	4.4	40	5.6	3.59	1.02, 12.68
Cumulative penetrating radiation dose (mSv)*						
0	25	13.9	103	14.3	1.0	
>0-50	126	70.0	504	70.2	0.91	0.47, 1.73
>50	29	16.1	111	15.5	0.98	0.40, 2.44
Period of first hire						
1951–1953	38	21.1	186	25.9	1.28	0.72, 2.54
1954–1959	40	22.2	175	24.4	1.29	0.71, 2.37
1960–1967	64	35.6	175	24.4	1.80	1.08, 3.05
1968–1989	38	21.1	182	25.4	1.0	
Length of employment (years)	180	100	718	99.7	0.96	0.94, 0.99
Years with above-zero dose	180	100	718	99.7	0.97	0.94, 0.99

\* 10-year lag period.

Table 23. Evaluation of selection bias with odds ratios for case and control groups defined by availability of smoking data, with and without adjustment for age at first dose Rocky Flats production era, 1952-1989

Model variables	Case-control pairs with smoking data		Unmatched subjects with smoking data		All subjects, missing-indicator variable	
	Adjustment for age at first internal lung dose					
	Adjusted* (n=344)	Not Adjusted† (n=549)	Adjusted* (n=448)	Not Adjusted‡ (n=730)	Adjusted* (n=510)	Not Adjusted† (n=898)
Cumulative internal lung dose (mSv)§						
0	1.0	1.0	1.0	1.0	1.0	1.0
>0 -100	1.41	1.22	1.62	1.34	1.43	1.40
>100-400	2.31	1.75	2.23	1.67	1.75	1.62
>400	3.73	2.35	3.66	2.42	2.45	2.20
Cumulative penetrating radiation dose (mSv)§						
0	1.0	1.0	1.0	1.0	1.0	1.0
>0-50	2.15	1.04	1.87	0.91	2.72	0.99
>50	2.72	1.25	2.21	0.98	2.98	0.93
Period of first hire						
1951-1953	1.55	1.03	1.13	0.92	1.35	1.33
1954-1959	1.54	0.97	1.31	1.00	1.71	1.29
1960-1967	2.57	1.53	2.07	1.48	2.45	1.84
1968-1989	1.0	1.0	1.0	1.0	1.0	1.0
Length of employment (years)	0.93	0.96	0.94	0.96	0.94	0.96
Age, first lung dose (years)	1.07		1.06		1.05	

\* Multiple logistic regression model, adjusted for birth year and for age at first internal lung dose.

† Conditional multiple logistic regression model, matched case-control pairs with smoking data for both subjects, not adjusted for age at first internal lung dose.

‡ Multiple logistic regression model, adjusted for birth year, not adjusted for age at first internal lung dose.

§ 10-year lag period.

Table 24. Comparison of odds ratios for models with and without adjustment for smoking frequency, Rocky Flats production era, 1952-1989

Model variables	Matched case-control pairs with smoking data* (n=549)		Unmatched subjects with smoking data† (n=730)		Matched, all subjects, missing-indicator variable ‡ (n=898)	
	Adjustment for smoking frequency					
	Adjusted§	Not adjusted¶	Adjusted§	Not adjusted¶	Adjusted§	Not adjusted¶
Cumulative internal lung dose (mSv)‡						
0	1.0	1.0	1.0	1.0	1.0	1.0
>0 –100	1.16	1.22	1.32	1.44	1.23	1.45
>100-400	1.85	1.71	1.84	1.80	1.52	1.63
>400	2.33	2.35	3.00	2.83	2.41	2.54
Cumulative penetrating radiation dose (mSv)‡						
0	1.0	1.0	1.0	1.0	1.0	1.0
>0-50	1.36	1.13	1.05	1.07	0.86	1.01
>50	1.48	1.39	0.91	1.06	0.79	1.00
Smoking frequency (pack-years)‡						
0	1.0		1.0		1.0**	
0.1-12.8	2.31		2.61		2.28	
>12.8-25.5	2.34		2.78		2.45	
>25.5-43.0	3.20		2.89		2.80	
>43.0	6.86		5.54		5.68	
Length of employment (years)	0.96	0.96	0.96	0.96	0.97	0.96

\* Conditional multiple logistic regression model, matched case-control pairs with smoking data for both subjects.

† Multiple logistic regression model, subjects with smoking data.

‡ Conditional multiple logistic regression model with missing indicator variable, all subjects regardless of smoking data availability.

§ Model adjusted for smoking frequency.

¶ Model adjusted for smoking frequency.

# 10-year lag period.

\*\* Zero pack-year category includes subjects with missing smoking data.